USE OF MODIFIED BIOASSESSMENT PROTOCOLS FOR EVALUATION OF WATER QUALITY

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INTRODUCTION

This study explored the potential for biotic evaluation of changes in water quality in the state of Georgia. Specific objectives were to: 1) evaluate application of EPA benthic assessment protocols for potential use in on-going water quality monitoring in Georgia; and 2) compare biomonitoring results with water quality indices based on physical-chemical monitoring.

Water quality monitoring in the U.S. has historically focused on physical-chemical data. The Georgia EPD currently conducts routine chemical monitoring of water quality at nearly 100 locations across the state. Additional data, including benthic counts, are collected at a subset of these stations. Physical-chemical data from a portion of this trend monitoring network have been used to calculate an index of overall water quality called the Trend Monitoring Index (TMI). This index of overall water quality was developed as a tool for communication with the general public. Improvement in index values represents movement toward water quality management goals. Index values for representative stations have been reported annually (EPD 1983) and can be compared with "natural" values determined for each physiographic province by EPD staff.

Development of Bioassessment Protocols

In the 1987 report, *Surface Water Monitoring: A Framework for Change*, the U.S. EPA recommended a focus on biotic assessment of water quality: "acceleration of development and application of promising biological monitoring techniques" (U.S. EPA 1987). This recommendation is based on evidence that measurement of the biotic component of aquatic ecosystems provides information about environmental stress that is missed by periodic or continuous monitoring of physical-chemical factors (Lenat et al 1980, Penrose and Lenat 1982). Aquatic organisms integrate the effects of a variety of pollutants and reflect short-term, critical fluctuations in water quality. In addition, the benthic community may indicate chronic exposure to sub-optimal conditions.

Biological indicators have been used for some time. Emphasis has been given to diversity indices (Washington 1984 Cairns and Dickson 1971). These indices are useful under conditions of severe organic pollution, but show less sensitivity in more ecologically complex situations. In a variety of situations, including non-point source stress and contamination with metals or insecticides, simple diversity indices may not adequately reflect water quality (Lenat et al 1980). Biotic indices, which incorporate measures of pollution tolerance for specific taxa and measures of community structure, seem to be more sensitive to fluctuations in water quality (Quigley 1982). Sensitivity can be further increased by use of multiple indices or metrics (Plafkin et al 1989).

The North Carolina Division of Environmental Management (DEM) has done extensive work on biological assessment of water quality (DEM 1988). Biotic evaluation is based on multi-habitat sampling. Three levels of metrics are used for assessment: single number summaries (taxa richness, mean density and a biotic index), specific taxonomic groups (density as % of total and taxa richness within the groups), and changes in populations of certain species (Lenat 1984). This approach has been used to evaluate the water quality impacts of road building, orchard pesticide use and general basin development (Penrose et al 1982).

Drawing in part from the North Carolina work, EPA recently developed three protocols for bioassessment using benthic macroinvertebrates. One is designed for preliminary screening and two are intended for site ranking. These protocols incorporate metrics on several taxonomic and ecological levels. Proposed metrics address community structure, community balance (with emphasis on proportion of intolerant taxa) and trophic composition. In contrast to the North Carolina procedures, the EPA protocols are oriented toward sampling the most productive habitat rather than multiple habitats.

The protocols were developed to assist states that do not have bioassessment protocols or are seeking alternatives to present programs (Plafkin et al 1989). The metrics are intended to be modified to reflect differences among regions of the country and stream conditions. In this study, existing water quality monitoring records were used for application of EPA metrics, analysis of responses over the period of record, and comparison of results with those for physical-chemical monitoring data.

METHODS

When biological monitoring was initiated by the Georgia EPA, stations were selected where a complex of pollutant effects was likely to be represented. While thirty-nine stations were sampled in 1973, only six riverine stations were sampled in 1983. These six stations, with 8 to 11 year periods of record, represent a selection of the major rivers in Georgia and a range of influences on water quality (Table 1). Sampling at benthic stations has been done annually with a limestone substrate sampler, appropriate for analysis of EPA metrics and providing a basis for evaluation of trends over time. EPA metrics were modified to meet the constraints of the EPD macroinvertebrate data set. Modifications reflect stream conditions and limitations in data collection. For example, the metric incorporating shredder abundance was not used because coarse particulate organic matter was not routinely sampled. Several metrics developed by Shackleford (1988) incorporate information on community structure beyond that used by EPA. Two of these metrics were used in data analysis for this study. All metrics were calculated for data aggregated at the family level and for data at the species (lowest practical taxon) level.

Metric results for monitoring stations are intended to be compared with results from ecoregional reference sites representing best possible conditions (Kilkelly Environmental Associates 1989). Georgia EPD is in the process of identifying reference sites and developing a reference data base. At the time of this writing, however, limited reference data are available for the three ecoregions represented in the EPD data sets. Results from pristine, short-term monitoring stations among the initial EPD biological monitoring systems were evaluated as reference data. Pristine stations tended to be located on smaller streams and so, applicable data are limited to a three-year record for one station upstream of metro Atlanta. Although ecoregional reference streams of similar size in neighboring states may be a future source of data, this study primarily focuses on use of bioassessment metrics without comparison to pristine reference sites.

For each metric, the EPA protocols specify scoring criteria for biological condition. Scores for all metrics are then composited in an assessment of degree of impairment in relation to a reference station. Lack of reference data necessitated substantial modification of EPA's biological scoring and bioassessment. Rather than evaluate degradation from best possible conditions, biological scoring criteria were defined to assess degree of change from preceding years. The EPA bioassessment categories were used to derive water quality categories ranging from significant improvement to significant degradation. Results of bioassessment of trends in water quality were compared with trends indicated by physical-chemical data (from EPA's STORET data base) and by historical values of the Trend Monitoring Index.

RESULTS AND CONCLUSIONS

As described by EPA, biotic assessment at the family level is intended as a prioritizing or screening procedure to detect sites of intermediate impairment. Species-level evaluation is a more rigorous technique designed to allow detection of more subtle degrees of impairment. In general, family- and species-level bioassessment of water quality in the six rivers met these objectives. For selected stations, however, family-level metrics indicated no change in water quality where species-level metrics indicated moderate to significant degradation in water quality. At these stations, family-level analysis also tended to show improvements more readily than species analysis. While biotic and physical-chemical indication of trends corresponded at some stations, qualitative comparison of bioassessments and historical TMI records did not generate results consistent across all stations.

EPA bioassessment protocols include three general types of metrics: based on direct counts of organisms at one station; based on ratios between taxonomic or functional groups at one station; and based on differences in composition between two stations. With two exceptions, the different types of metrics performed equally well. Because functional group was not determined morphologically at the time of sampling, metrics based on functional composition showed substantial year-to-year variation. Metrics based on ratios between taxonomic groups of widely differing densities also showed significant year-to-year variation. As indicated in earlier work, use of a greater number of non-redundant metrics increased the sensitivity of water quality evaluation.

The lack of a reference data base seriously limits use of EPA metrics for evaluation of trends in water quality in Georgia. At the same time, annual sampling at each site with a single limestone substrate sampler limits the rigor of conventional statistical approaches to trend analysis. Biological monitoring is increasingly being recognized as an important component of a comprehensive monitoring program. A monitoring program that meets rigorous statistical requirements, however, would require a significant increase in the investment in biotic monitoring made by the State of Georgia.

The EPA protocols define a system for routine biological monitoring with consistent unit of effort and systematic data analysis. Georgia EPD has begun multi-habitat sampling in a manner consistent with EPA protocols and has begun development of a reference data base. Once a reference data base is developed and routine bioassessment is institutionalized, this system could easily be extended to stations which cover the range of stream types and water quality influences found across the state. Based on our preliminary results, we recommend that the State of Georgia commit the resources necessary for effective use of the bioassessment protocols and extend the long-term biomonitoring system beyond the six stations analyzed in the report.

Table 1. Long-term Biological Monitoring Stations

River	Major water quality influences
Flint River Fayette County Piedmont Province	Treated waste waters from Atlanta and Fayetteville
South River Atlanta Newton County Piedmont Province and	Station is influenced by and several treated discharges into tributaries (municipal private facilities)
Savannah River Richmond County Coastal Plain Province	Augusta, Fort Gordon wastewater discharge to tributaries
Conasauga River Murray County Ridge and Valley Province	Initially, wastewater from Dalton; Dalton has now converted to land treatment
Chattahoochee River Douglas County Piedmont Province	Wastewater discharge from Fulton and Cobb counties; water level varies from peak power generation
Ocmulgee River waste Twiggs County Coastal Plain Province	Municipal and industrial waters from Macon

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